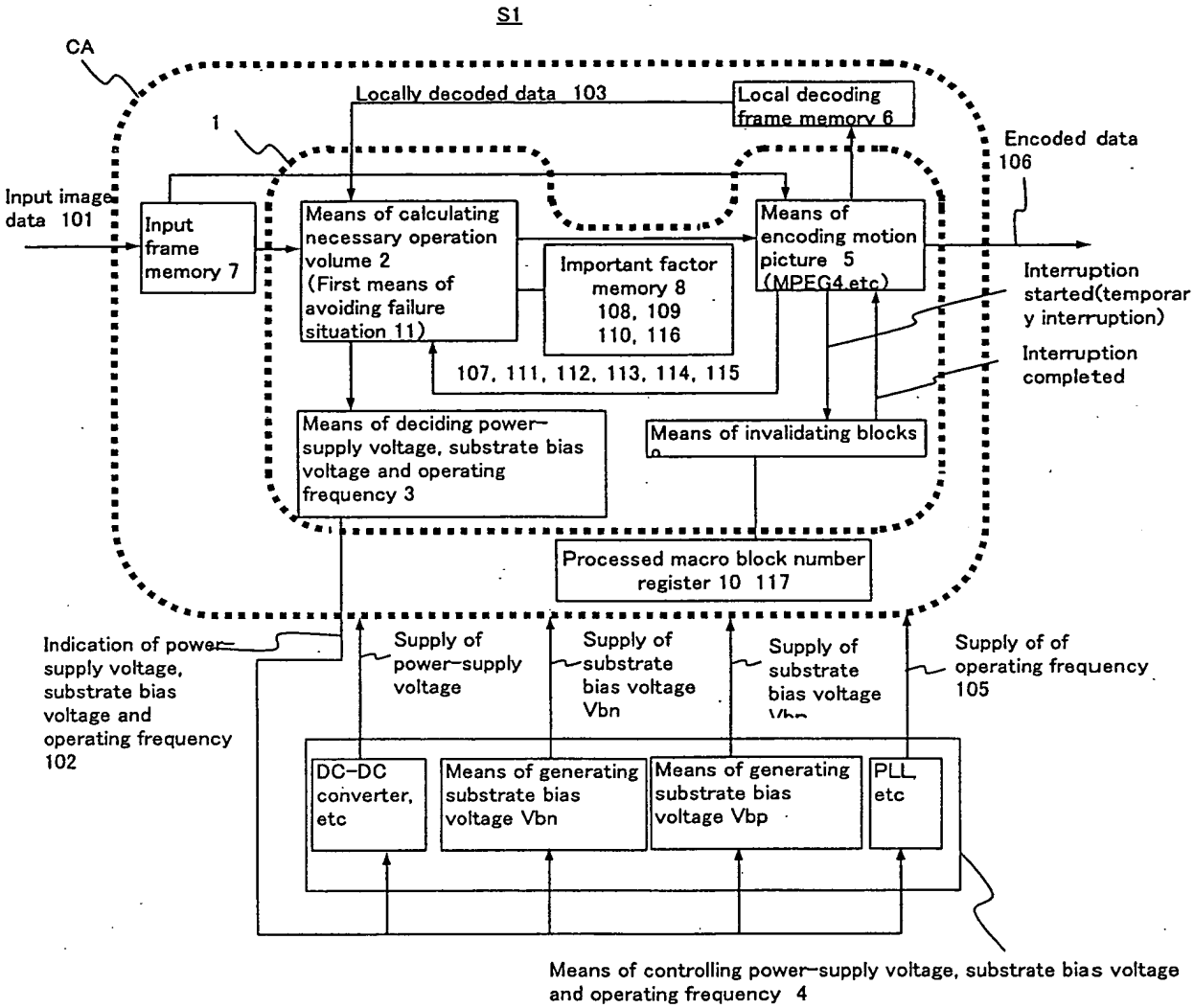
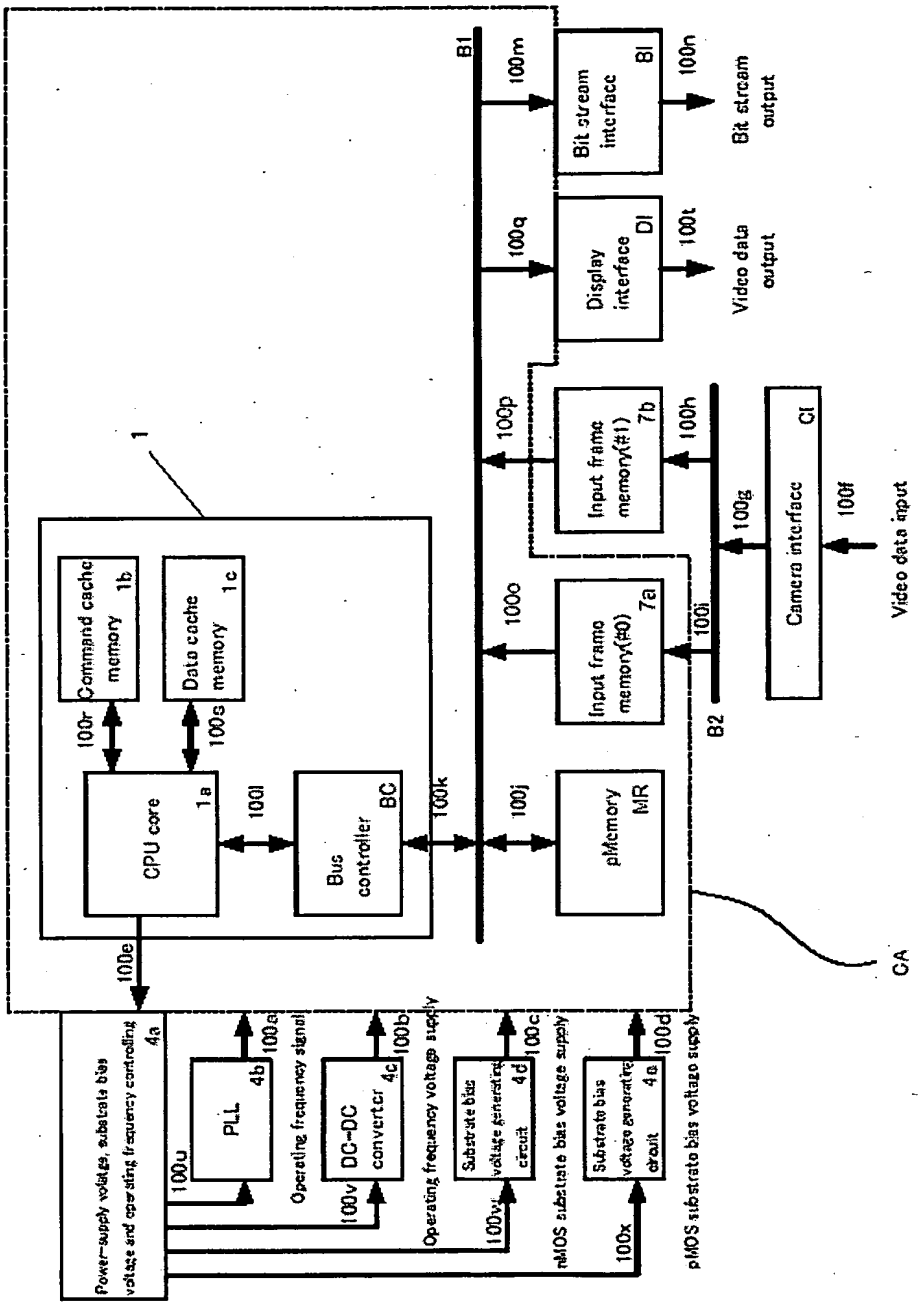
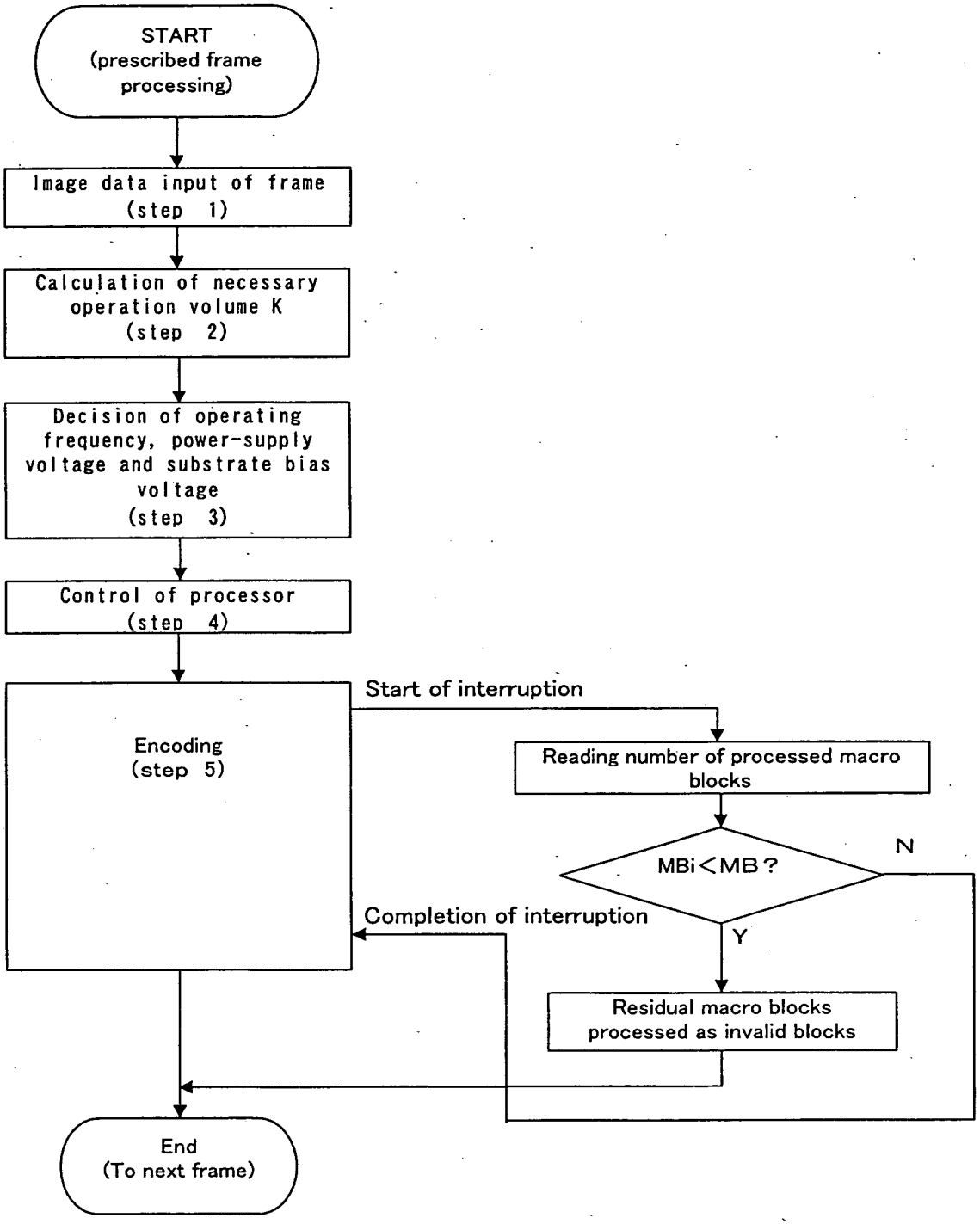
【Fig1】


S1
CA
1
Locally decoded data 103
Local decoding frame memory 6
Encoded data 106
Input image data 101
Input frame memory 7
Means of calculating necessary operation volume 2 (First means of avoiding failure situation 11)
Important factor memory 8 108, 109 110, 116
Means of encoding motion picture 5 (MPEG4,etc)
Interruption started(temporary interruption)
Interruption completed
107, 111, 112, 113, 114, 115
Means of deciding power-supply voltage, substrate bias voltage and operating frequency 3
Means of invalidating blocks
Processed macro block number register 10 117
Indication of power-supply voltage, substrate bias voltage and operating frequency 102
Supply of power-supply voltage
Supply of substrate bias voltage Vbn
Supply of substrate bias voltage
Supply of of operating frequency 105
DC-DC converter, etc
Means of generating substrate bias voltage Vbn
Means of generating substrate bias voltage Vbp
PLL etc
Means of controlling power-supply voltage, substrate bias voltage and operating frequency 4

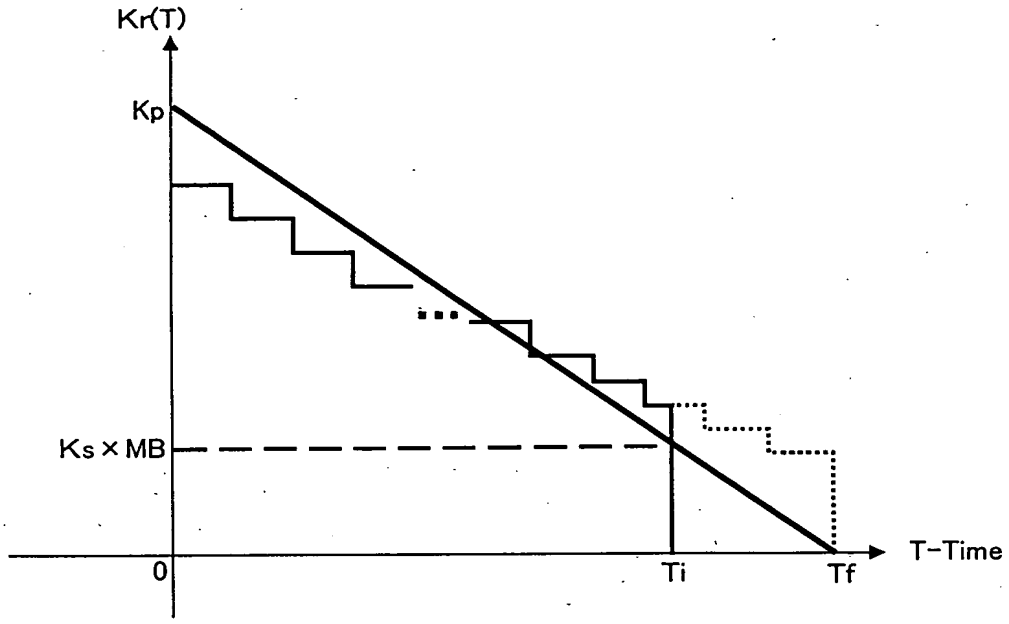
【Fig2】


1
Command cache memory 1b
Data cache memory 1c
CPU core 1a
Bus controller BC
pMemory MR
Input frame memory(#0) 7a
Input frame memory(#1) 7b
Camera interface CI
Display interface DI
Bit stream interface BI
Video data input
Video data output
Bit stream output
B1
B2
CA
100e
100f
100g
100h
100i
100j
100k
100l
100m
100n
100o
100p
100q
100r
100s
100t
Power-supply voltage, substrate bias voltage and operating frequency controlling 4a
PLL 4b
DC-DC converter 4c
Substrate bias voltage generating circuit 4d
Substrate bias voltage generating circuit 4e
100u
100v
100w
100x
100a
100b
100c
100d
Operating frequency signal
Operating frequency voltage supply
nMOS substrate bias voltage supply
pMOS substrate bias voltage supply

【Fig3】


START
(prescribed frame processing)
Image data input of frame
(step 1)
Calculation of necessary operation volume K
(step 2)
Decision of operating frequency, power-supply voltage and substrate bias voltage
(step 3)
Control of processor
(step 4)
Encoding
(step 5)
Start of interruption
Reading number of processed macro blocks
MBi<MB?
N
Y
Completion of interruption
Residual macro blocks processed as invalid blocks
End
(To next frame)

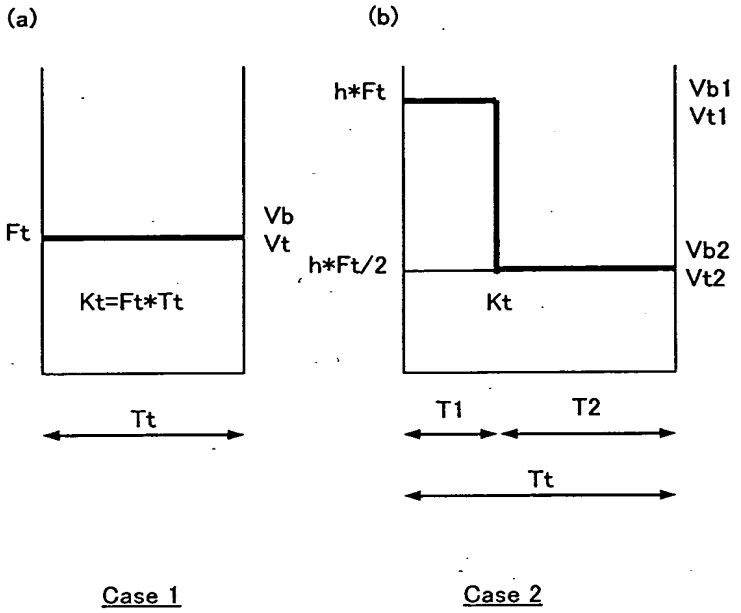
【Fig4】



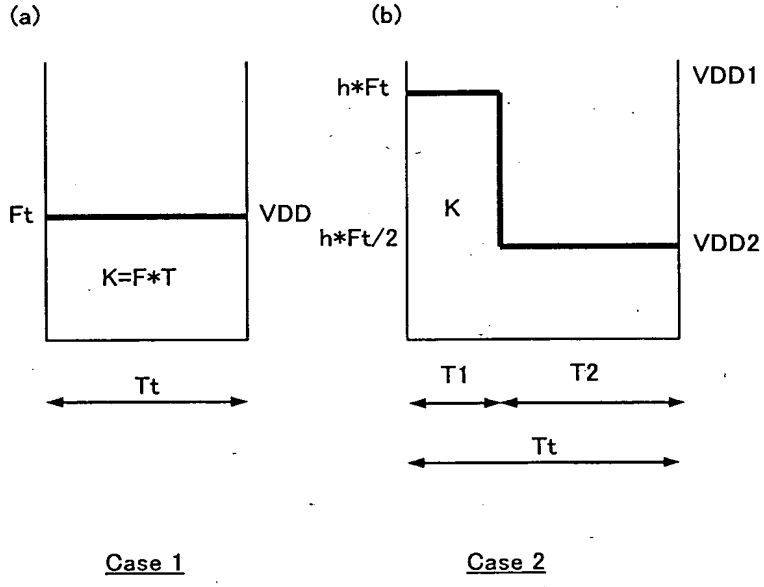
【Fig5】

Operating frequency (cycles／second)	Power-supply voltage (VDD)	Substrate bias voltage of n-channel MOS transistor (Vbn)	Substrate bias voltage of p-channel MOS transistor (Vbp)
f (1)	VDD (1)	Vbn (1)	Vbp (1)
f (2) (>f (1))	VDD (2)	Vbn (2)	Vbp (2)
f (3) (>f (2))	VDD (3)	Vbn (3)	Vbp (3)
・	・	・	・
f (n) (>f (n−1))	VDD (n)	Vbn (n)	Vbp (n)
・	・	・	・
f (r) (>f (r−1))	VDD (r)	Vbn (r)	Vbp (r)

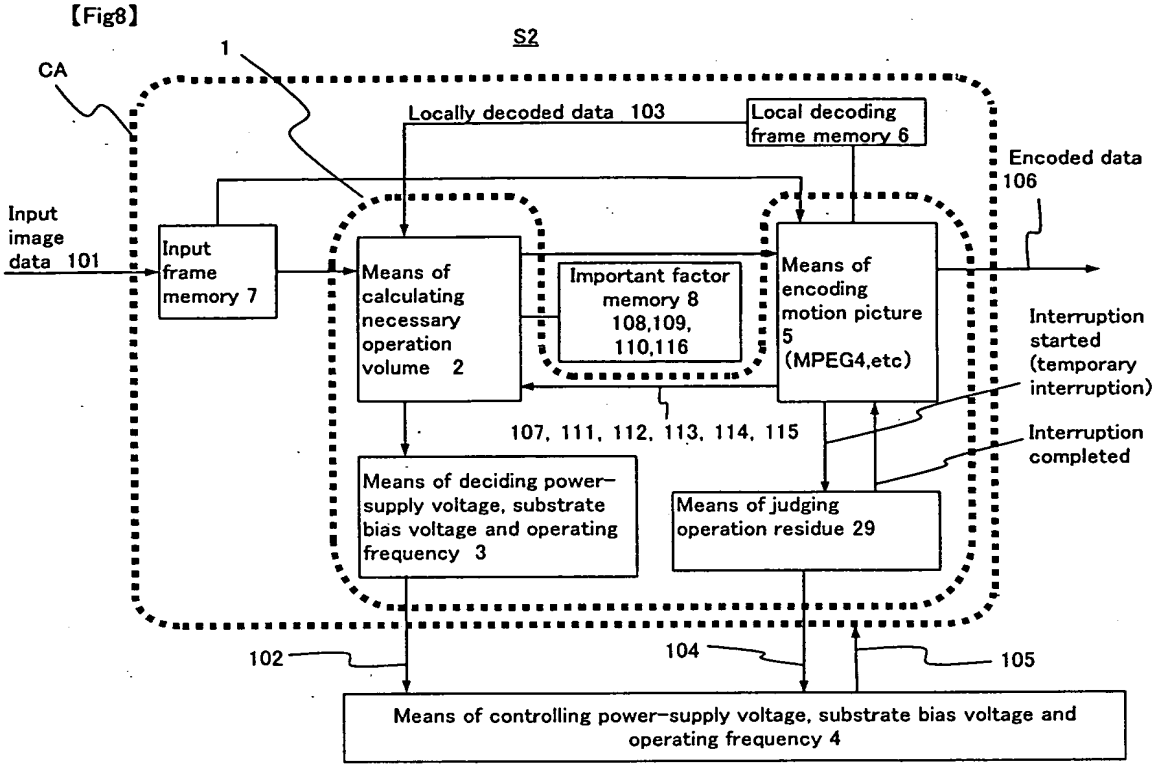
【Fig6】


(a)
(b)
Ft
Vb
Vt
Kt=Ft*Tt
Tt
h*Ft
Vb1
Vt1
h*Ft/2
Vb2
Vt2
Kt
T1
T2
Tt
Case 1
Case 2

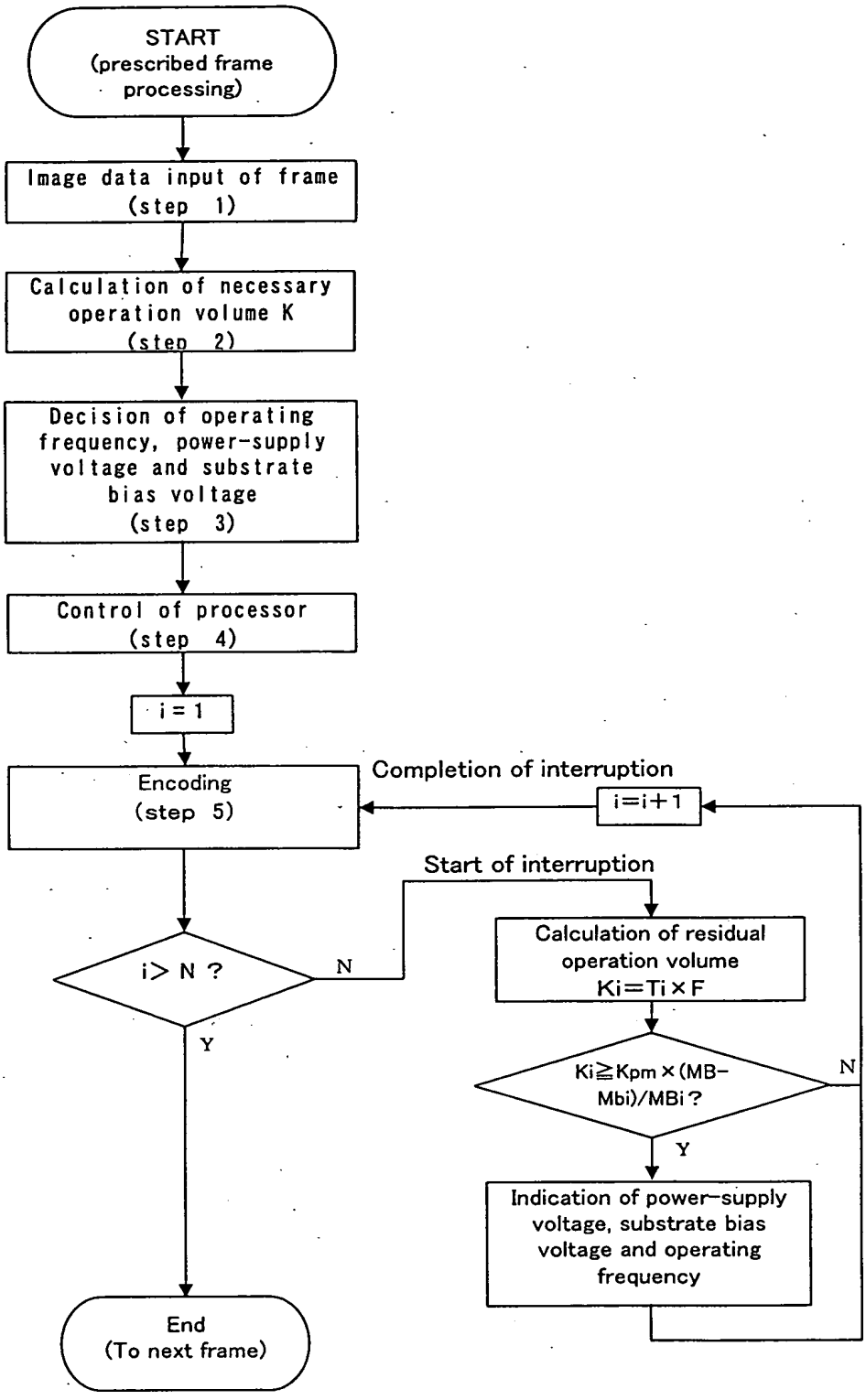
【Fig7】


(a)
(b)
Ft
VDD
K=F*T
Tt
h*Ft
VDD1
K
h*Ft/2
VDD2
T1
T2
Tt
Case 1
Case 2

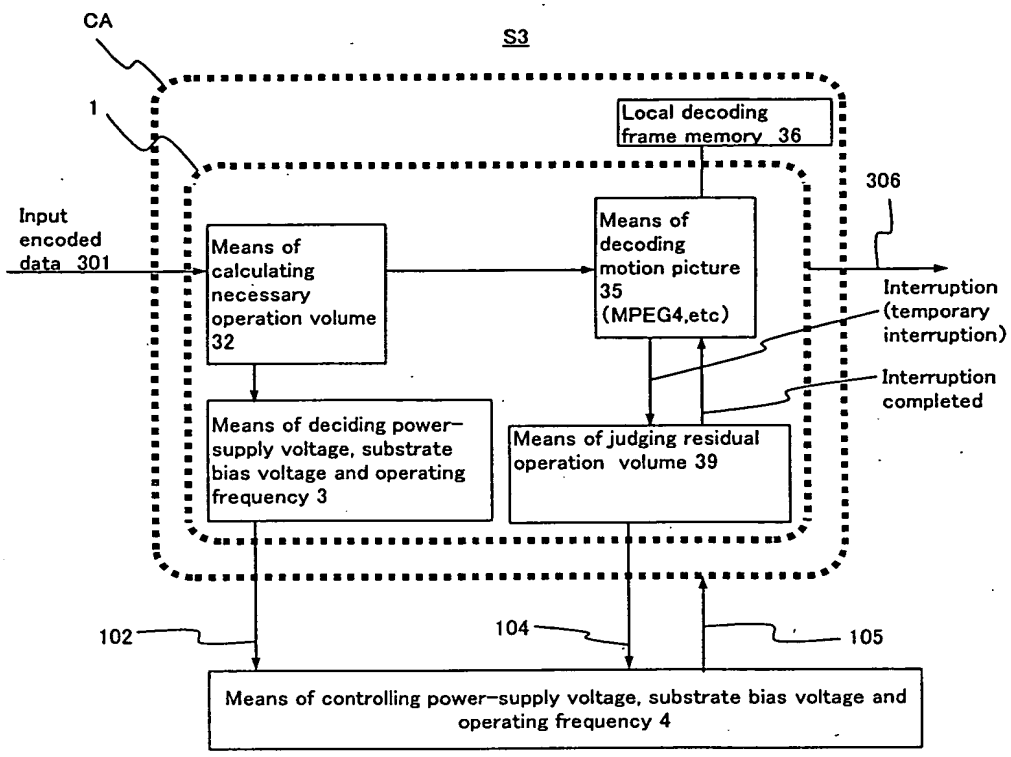
【Fig8】


S2
1
CA
Locally decoded data 103
Local decoding frame memory 6
Encoded data 106
Input image data 101
Input frame memory 7
Means of calculating necessary operation volume 2
Important factor memory 8 108,109, 110,116
Means of encoding motion picture 5 (MPEG4,etc)
Interruption started (temporary interruption)
107, 111, 112, 113, 114, 115
Interruption completed
Means of deciding power-supply voltage, substrate bias voltage and operating frequency 3
Means of judging operation residue 29
102
104
105
Means of controlling power-supply voltage, substrate bias voltage and operating frequency 4

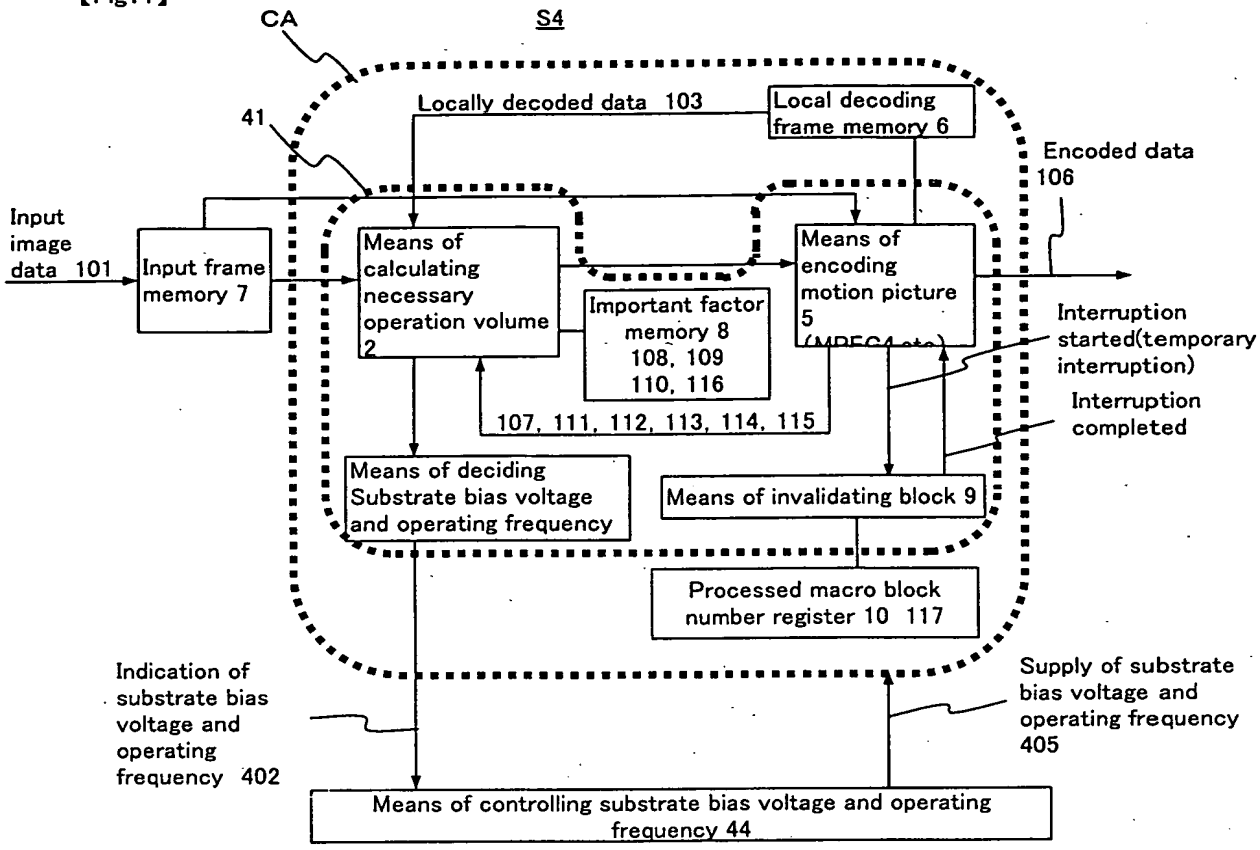
【Fig9】


START
(prescribed frame processing)
Image data input of frame
(step 1)
Calculation of necessary operation volume K
(step 2)
Decision of operating frequency, power-supply voltage and substrate bias voltage
(step 3)
Control of processor
(step 4)
i = 1
Encoding
(step 5)
Completion of interruption
i=i+1
Start of interruption
i> N ?
N
Y
Calculation of residual operation volume
Ki=Ti×F
Ki≧Kpm×(MB-Mbi)/MBi?
N
Y
Indication of power-supply voltage, substrate bias voltage and operating frequency
End
(To next frame)

【Fig10】


CA
S3
1
Local decoding frame memory 36
306
Input encoded data 301
Means of calculating necessary operation volume 32
Means of decoding motion picture 35 (MPEG4,etc)
Interruption (temporary interruption)
Interruption completed
Means of deciding power-supply voltage, substrate bias voltage and operating frequency 3
Means of judging residual operation volume 39
102
104
105
Means of controlling power-supply voltage, substrate bias voltage and operating frequency 4

【Fig11】


CA
S4
41
Locally decoded data 103
Local decoding frame memory 6
Encoded data 106
Input image data 101
Input frame memory 7
Means of calculating necessary operation volume 2
Important factor memory 8 108, 109 110, 116
Means of encoding motion picture 5
Interruption started(temporary interruption)
Interruption completed
107, 111, 112, 113, 114, 115
Means of deciding Substrate bias voltage and operating frequency
Means of invalidating block 9
Processed macro block number register 10 117
Indication of substrate bias voltage and operating frequency 402
Supply of substrate bias voltage and operating frequency 405
Means of controlling substrate bias voltage and operating frequency 44

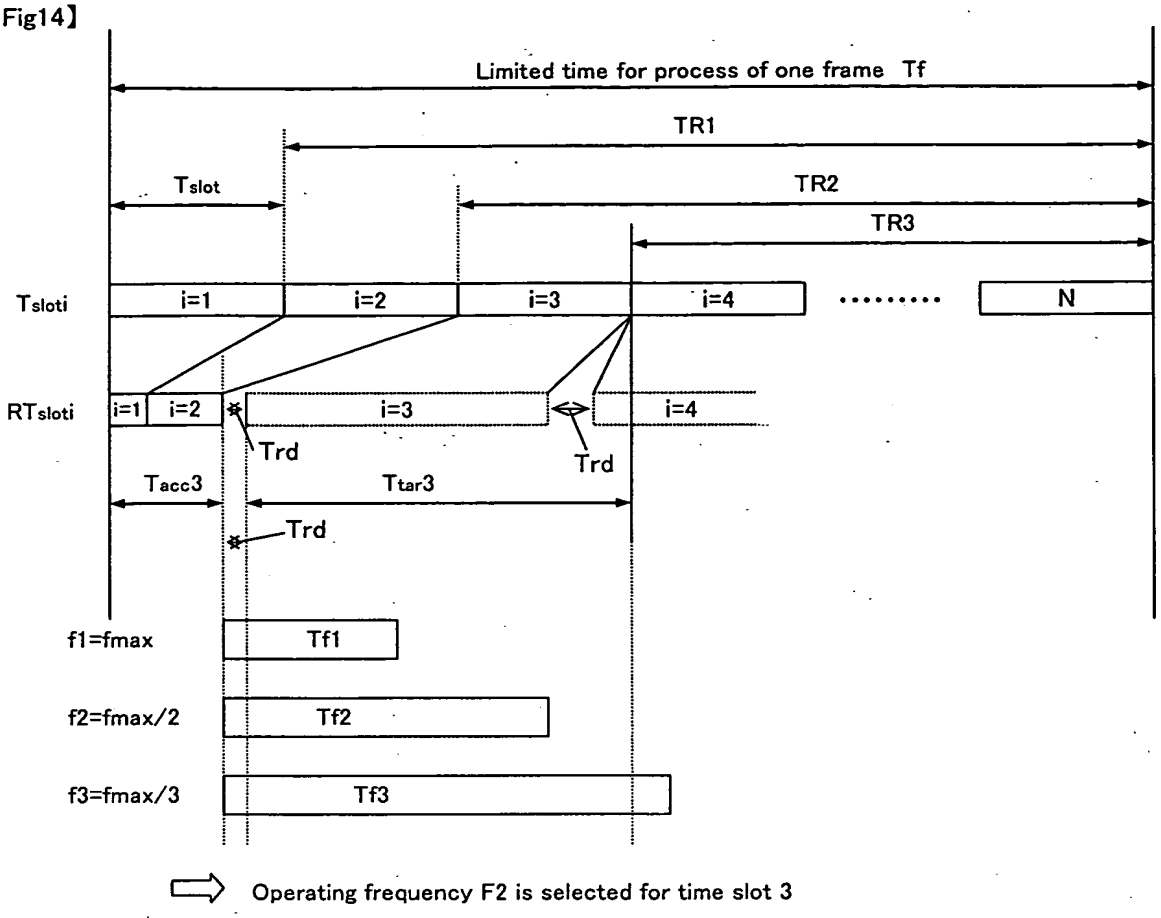
【Fig12】

Operating frequency (cycles／second)	Substrate bias voltage of n-channel MOS transistor (Vbn)	Substrate bias voltage of p-channel MOS transistor (Vbp)
f (1)	Vbn (1)	Vbp (1)
f (2) (>f (1))	Vbn (2)	Vbp (2)
f (3) (>f (2))	Vbn (3)	Vbp (3)
.	.	.
f (n) (>f (n−1))	Vbn (n)	Vbp (n)
.	.	.
f (r) (>f (r−1))	Vbn (r)	Vbp (r)

【Fig13】

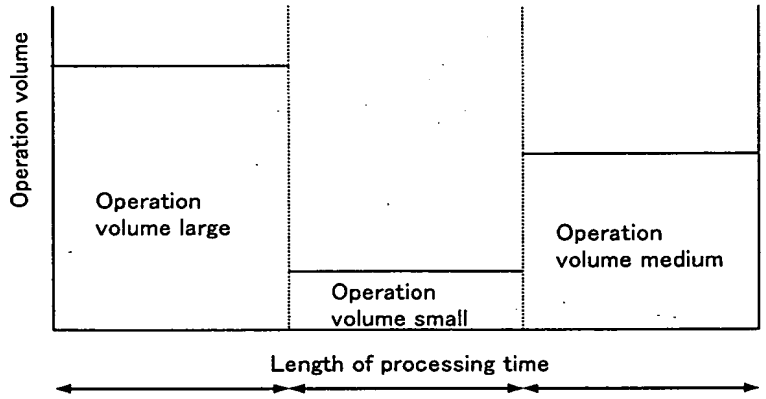
Operating frequency (cycles／second)	Power-supply voltage (VDD)	Substrate bias voltage of n-channel MOS transistor (Vbn)	Substrate bias voltage of p-channel MOS transistor (Vbp)
f (1)＝50	VDD(1)＝0.5	Vbn (1) = −1.0	Vbp (1) = 1.5
f (2)＝100	VDD(2)＝0.6	Vbn (2) = −0.4	Vbp (2) = 1.0
f (3)＝150	VDD(3)＝0.8	Vbn (3) = 0	Vbp (3) = 0.8
f (4)＝200	VDD(4)＝0.9	Vbn (4) = 0.2	Vbp (4) = 0.7
f (5)＝250	VDD(5)＝1.0	Vbn (5) = 0.5	Vbp (5) = 0.5

【Fig14】

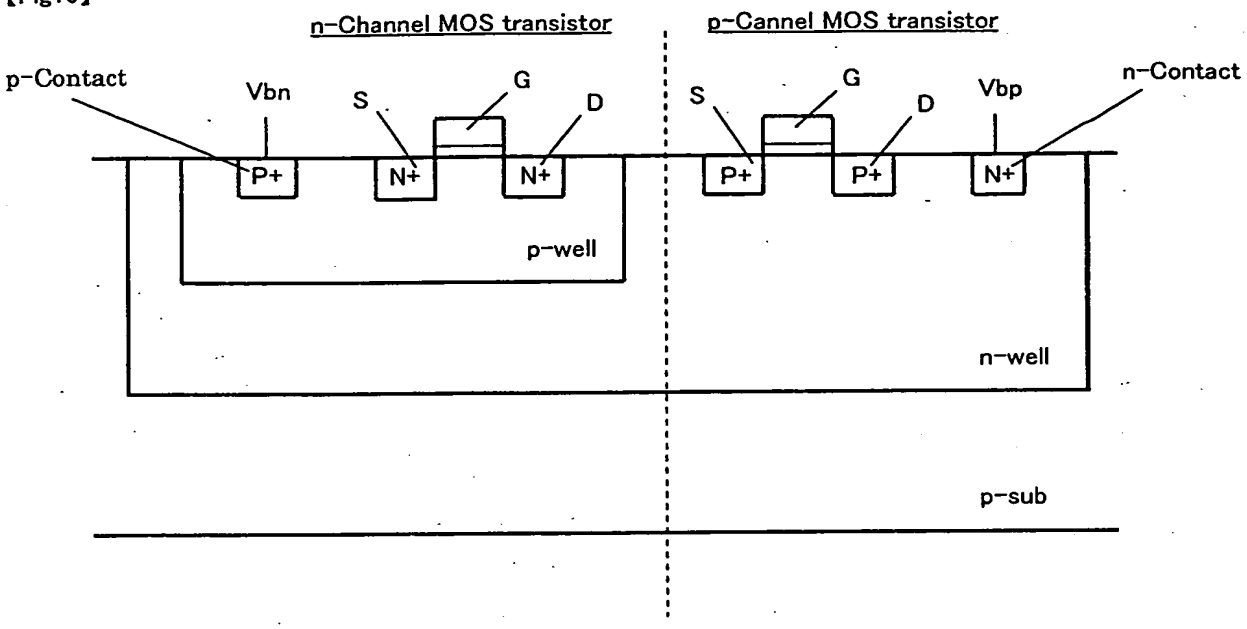


⇨ Operating frequency F2 is selected for time slot 3

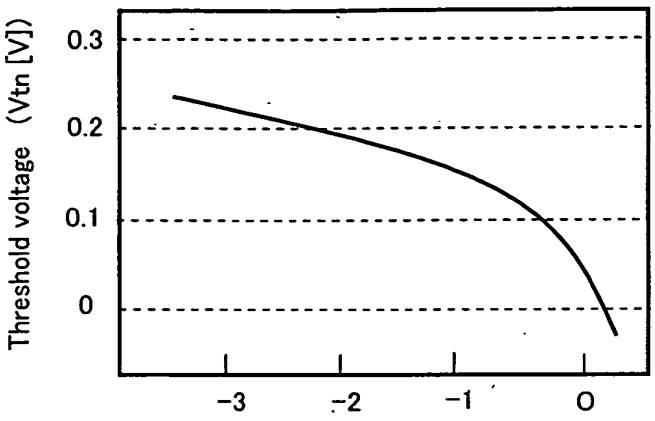
【Fig15】



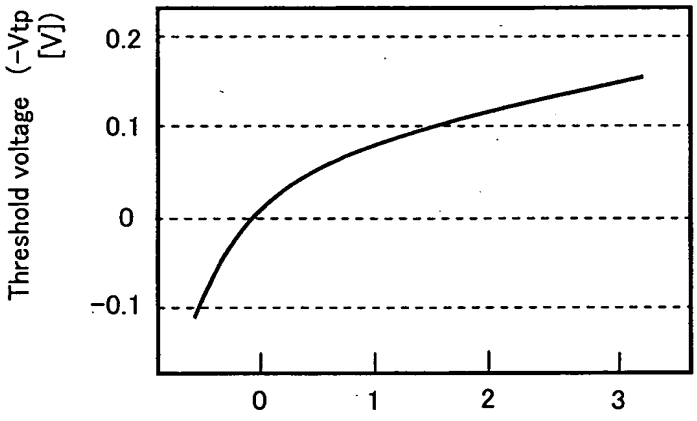
【Fig16】


n-Channel MOS transistor
p-Cannel MOS transistor
p-Contact
Vbn
S
G
D
S
G
D
Vbp
n-Contact
P+
N+
N+
P+
P+
N+
p-well
n-well
p-sub

【Fig17】

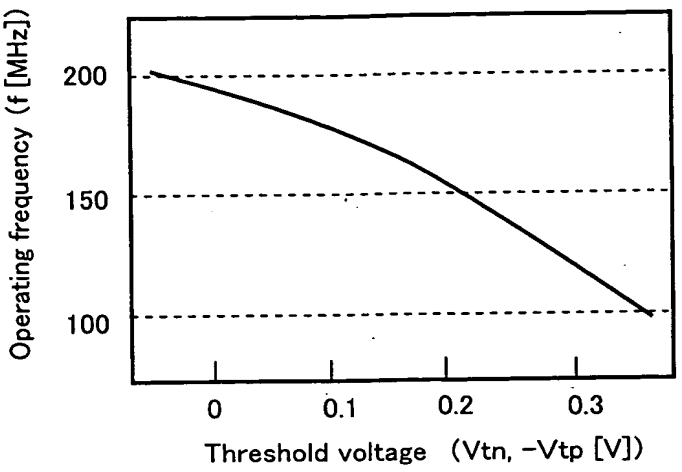


n-Channel MOS transistor

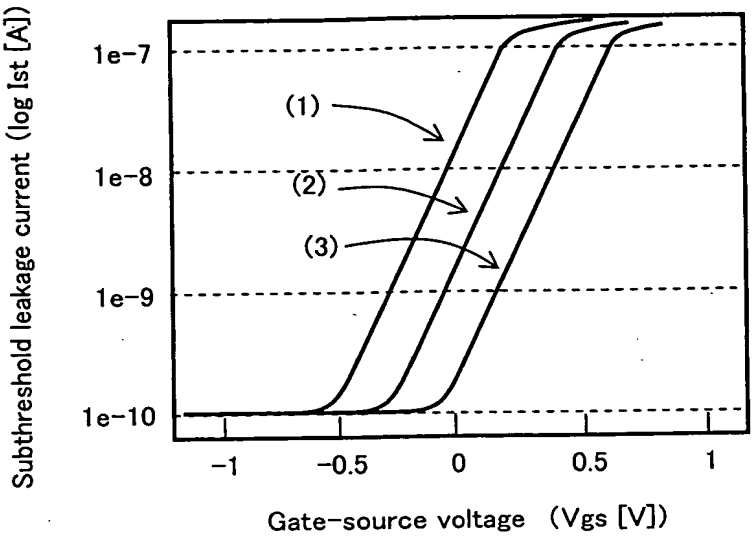


p-Channel MOS transistor

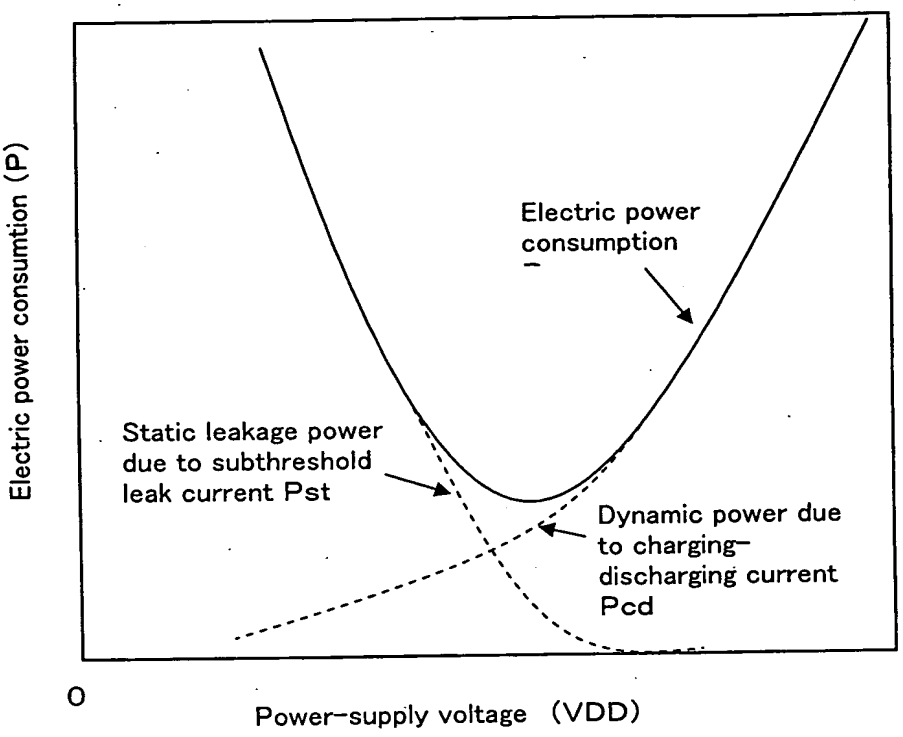
【Fig18】


Operating frequency (f [MHz])
200
150
100
0
0.1
0.2
0.3
Threshold voltage (Vtn, −Vtp [V])

【Fig19】


Subthreshold leakage current (log Ist [A])
1e-7
1e-8
1e-9
1e-10
(1)
(2)
(3)
-1
-0.5
0
0.5
1
Gate-source voltage (Vgs [V])

【Fig20】


Electric power consumtion (P)
Electric power consumption
Static leakage power due to subthreshold leak current Pst
Dynamic power due to charging-discharging current Pcd
0
Power-supply voltage (VDD)